A Red Pine Case History: Development of the Rockland Plantation From 1914 to 1986

by F.W. von Althen¹ and W.M. Stiel²

Abstract

Growth data are presented for a 72-year-old plantation of red pine (*Pinus resinosa* Ait.) at Rockland, Ontario, part of which was thinned four times between 1938 and 1972 and part of which was left unthinned. Height growth in both parts ceased between stand ages 67 and 72 years. During the same 5-year period, gross periodic increment was 551 ft³/ac (38.6 m³/ha) in the thinned stand while in the unthinned stand mortality exceeded gross periodic increment by 187 ft³/ac (13.1 m³/ha).

Résumé

Ce rapport présente des données sur la croissance d'une plantation de pins rouges (*Pinus resinosa* Ait.) de 72 ans située à Rockland, en Ontario; une partie de cette plantation a été éclaircie à quatre reprises de 1938 à 1972 et l'autre partie est restée intouchée. L'accroissement en hauteur s'est interrompu dans les deux parties entre l'âge de 67 et de 72 ans. Pendant cette même période de 5 ans, l'accroissement périodique brut était de 36,8 m³/ha (551 pi³/acre) dans le peuplement éclairci tandis que la mortalité dépassait l'accroissement périodique brut de 13,1 m³/ha (187 pi³/acre) dans le peuplement non éclairci.

Introduction

One of the oldest plantations of red pine (*Pinus resinosa* Ait.) in Ontario is a stand at Rockland, ca. 40 km east of Ottawa, whose 48 years of recorded development make it a valuable source of management information for this species. Growth of the plantation from 1938 to 1981 has been documented in eight publications (Sisam 1939; Mulloy 1943, 1946; Stiel 1953, 1957; von Althen and Stiel 1965, 1982; von Althen *et al.* 1978); the present report, which summarizes growth and yield to 1986, will be the last. Recent unauthorized cutting in the plantation sample plots has compromised realistic growth estimates and effectively terminated the experiment.

Stand Description, Measurements and Compilations

The plantation was established in 1914, when 3-year-old seedlings were planted at a spacing of 6 × 6 ft (1.8 × 1.8 m)³ in an abandoned pasture. The soil was a water-washed till on the western portion of the area, changing to dry, interbanded sand and silt loam to the east. Site index on the basis of the height of the dominant trees was 75 ft (23 m) 50 years after planting.

In 1938, two 0.5-acre (0.202-ha) permanent sample plots were established. Trees in one plot were pruned and thinned in that year, and were thinned again in 1951, 1961 and 1971, but the other plot was not treated then or subsequently. Both plots were remeasured in 1943, and every 5 years from 1951 to 1986 inclusive.

Measurement and compilation procedures were as follows. All trees within the plots were numbered and their positions plotted on a large-scale map. The outside-bark breast-height diameters (DBH) of all numbered trees were taken to the nearest 0.01 in (0.025 cm) and a stand table was constructed, with 1-in (2.54-cm) diameter classes. The heights of 10 to 15 trees in each diameter class were measured to the nearest

1 ft (30.48 cm) and height/diameter curves were drawn. From these curves, total cubic-foot volume was computed for each diameter class, and the merchantable cubic-foot volume was calculated for all trees with DBH ≥ 6 in (15.24 cm), by means of the volume tables for red pine trees younger than 120 years with form class 70 (Anon. 1948). The merchantable board-foot volume was compiled for all trees of DBH ≥ 8 in (20.32 cm) by means of the International Log Rule (1/4) (Anon. 1948).

Stand Treatments

Thinning

The first thinning, in 1938, was relatively light because of a fear of windthrow and the small size of the material, which could be sold for fuelwood only. Poorly formed and badly suppressed trees were marked for removal to provide more growing space for the most promising individuals and to leave a uniform stand with a well broken canopy.

Thinnings in 1951 and 1961 were aimed at the release of 160 selected crop trees per acre (395 trees/ha) as well as the removal of unthrifty and suppressed trees that were not expected to survive the next decade. Though all trees marked for the 1951 thinning were cut, only 82 of the 128 trees marked in 1961 were removed because of poor health of the plantation owner.

The final thinning in 1971 removed all but the 160 designated crop trees per acre (395 trees/ha). The decision to apply a final thinning at this time was based on the density of the canopy which, of course, was partly the result of the unfinished logging in 1961. It was also thought that the large, tall trees could be removed efficiently only by a large rubber-tired tractor. This required sufficient space to avoid damage to the residual trees. The thinning was carried out by a jobber who felled the trees with a chainsaw and skidded them full length to the landing with a wheeled skidder.

Pruning

In 1938, all trees in the managed stand were pruned with saws to a height of 20 ft (6.1 m). In addition to the removal of all dead branches, two or three whorls of living branches were cut, leaving a live crown of approximately 50% of tree

¹Research Scientist, Forestry Canada, Ontario Region, Great Lakes Forestry Centre, Sault Ste. Marie, Ontario.

²Emeritus Research Scientist, Forestry Canada, Petawawa National Forestry Institute, Chalk River, Ontario.

³Original measurements were taken in Imperial units; hence, both Imperial and metric units are used throughout this paper.

Table 1a. Summary of growth data for the thinned stand and the control (Imperial units).

Age from planting (Age from seed)	Year ¹	No. trees/ac		Basal area (ft ²)		Total vol. (ft ³)		Merch. vol. ² (ft ³)		Merch. vol. ³ (fbm)	
		Thinned	Control	Thinned	Control	Thinned	Control	Thinned	Control	Thinned	Control
24 (27)	1938										
	BT	912	976	193	201	3681	3820	2349	2364	1488	2096
	T	322	—	53	—	1000	—	488	—	90	—
	AT	590	976	140	201	2681	3820	1861	2364	1398	2096
29 (32)	1943										
	BT	582	884	157	208	3408	4475	2547	3032	5353	4366
	GPI	—	—	18	20	752	896	703	676	3955	2270
	M	8	92	1	13	25	241	17	8	0	0
37 (40)	1951										
	BT	566	802	184	212	4725	5366	3825	4059	13406	9018
	T	162	—	40	—	1001	—	719	—	1422	—
	AT	404	802	144	212	3724	5366	3106	4059	11984	9018
	GPI	—	—	30	17	1385	1179	1303	1178	8067	4652
	M	16	82	3	13	68	288	25	151	25	0
42 (45)	1956										
	BT	404	730	161	216	4609	5949	3925	4702	17963	13790
	GPI	—	—	17	15	885	849	819	827	5979	4772
	M	0	72	0	11	0	266	0	184	0	0
47 (50)	1961										
	BT	400	678	179	223	5476	6753	4704	5470	23309	20250
	T	82	—	32	—	968	—	816	—	3575	—
	AT	318	678	147	223	4508	6753	3888	5470	19374	20250
	GPI	—	—	19	16	891	1047	798	937	5346	6460
	M	4	52	1	9	24	243	19	169	0	0
52 (55)	1966										
	BT	318	630	165	231	5457	7380	4770	6173	25711	26378
	GPI	—	—	18	17	949	895	882	899	5977	6220
	M	0	48	0	9	0	268	0	196	0	92
57 (60)	1971										
	BT	314	550	180	224	6211	7625	5405	6557	30812	31228
	T	154	—	73	—	2468	—	2113	—	11366	—
	AT	160	550	107	224	3743	7625	3292	6557	19446	31228
	GPI	—	—	16	11	791	783	665	795	5217	5094
	M	4	80	1	18	37	538	30	411	116	244
62 (65)	1976										
	BT	158	512	117	227	4291	8175	3839	6942	22612	35736
	GPI	—	—	11	13	590	858	583	625	3378	4850
	M	2	38	1	10	42	308	36	240	212	342
67 (70)	1981										
	BT	158	460	130	219	4844	8190	4398	7137	26382	38892
	GPI	—	—	13	6	553	496	559	563	3770	3890
	M	0	52	0	14	0	481	0	368	0	734
72 (75)	1986										
	BT	154	388	144	207	5395	8003	4884	6971	29110	38830
	GPI	—	—	16	11	620	620	547	480	3068	2062
	M	2 ⁴	62 ⁵	2	23	69	807	61	646	340	2124

¹BT, before thinning; T, thinning; AT, after thinning; GPI, gross periodic increment; M, mortality.²trees $\geq$ 6 in. DBH.³trees $\geq$ 8 in. DBH.⁴An additional two trees were cut by vandals.⁵An additional 10 trees were cut by vandals.

height. On the control plot, pruning removed only dead branches to head height for ease of stand access.

Stand Development

Growth data for both plots are shown in Tables 1a (Imperial units) and 1b (metric units) to allow easy comparison with data from other studies. Merchantable volume in board feet (fbm) was not converted into metric units because conversion factors vary among size classes.

Table 2 contains mean stand values of DBH and height for the thinned stand and the control from 1938 to 1986. In 1986, the average heights of dominants and codominants combined were 93 ft (28.3 m) and 92 ft (28.0 m) for the thinned stand and the control, respectively. These heights have not changed since 1981, which indicates that height growth stopped approximately 67 years after planting.

Basal area in the control plot reached a maximum of 231 ft²/ac (53.0 m²/ha) 52 years after planting and declined

Table 1b. Summary of growth data for the thinned stand and the control (metric units).

Age from planting	Year ¹	No. trees/ha		Basal area (m ²)		Total vol. (m ³)		Merch. vol. ² (m ³)	
		Thinned	Control	Thinned	Control	Thinned	Control	Thinned	Control
24	1938								
	BT	2254	2412	44.3	46.1	257.6	267.3	164.3	165.4
	T	796	—	12.1	—	70.0	—	34.1	—
	AT	1458	2412	32.2	46.1	187.6	267.3	130.2	165.4
29	1943								
	BT	1438	2184	36.1	47.7	238.5	313.1	178.2	212.1
	GPI	—	—	4.1	4.6	52.6	62.7	49.2	47.3
	M	20	228	0.2	3.0	1.7	16.9	1.2	0.6
37	1951								
	BT	1398	1982	42.3	48.6	330.6	375.5	267.6	284.0
	T	400	—	9.2	—	70.0	—	50.3	—
	AT	998	1982	33.1	48.6	260.6	375.5	217.3	284.0
	GPI	—	—	6.9	3.9	96.9	82.5	91.2	82.4
	M	40	202	0.7	3.0	4.8	20.1	1.8	10.5
42	1956								
	BT	998	1804	37.0	49.5	322.5	416.3	274.6	329.0
	GPI	—	—	3.9	3.4	61.9	59.4	57.3	57.9
	M	0	178	0	2.5	0	18.6	0	12.7
47	1961								
	BT	988	1675	41.1	51.2	383.1	472.5	329.1	382.7
	T	202	—	7.4	—	67.7	—	57.1	—
	AT	786	1675	33.7	51.2	315.4	472.5	272.0	382.7
	GPI	—	—	4.3	3.7	62.3	73.2	55.8	65.5
	M	10	129	0.2	2.0	1.7	17.0	1.3	11.8
52	1966								
	BT	786	1557	37.8	53.0	381.8	516.4	333.7	431.9
	GPI	—	—	4.1	3.9	66.4	62.6	61.7	62.9
	M	0	118	0	2.1	0	18.7	0	13.7
57	1971								
	BT	775	1359	41.3	51.4	434.6	533.6	378.2	458.8
	T	380	—	16.7	—	172.7	—	147.9	—
	AT	395	1359	24.6	51.4	261.9	533.6	230.3	458.8
	GPI	—	—	3.7	2.5	55.3	54.8	46.6	55.6
	M	10	198	0.2	4.1	2.5	37.6	2.1	28.7
62	1976								
	BT	390	1265	26.9	52.1	300.3	572.0	268.6	485.7
	GPI	—	—	2.5	3.0	41.3	60.0	40.8	43.7
	M	5	94	0.2	2.3	2.9	21.5	2.5	16.8
67	1981								
	BT	390	1137	29.9	50.2	339.0	573.1	307.7	499.4
	GPI	—	—	3.0	1.4	38.7	34.7	39.1	39.4
	M	0	128	0	3.2	0	33.6	0	25.7
72	1986								
	BT	380	959	33.1	47.5	377.5	560.0	341.7	487.8
	GPI	—	—	3.7	2.6	43.3	43.4	38.3	33.6
	M	10 ³	178 ⁴	0.5	5.3	4.8	56.5	4.3	45.2

¹BT, before thinning; T, thinning; AT, after thinning; GPI, gross periodic increment; M, mortality.²Tree ≥ 15.24 cm.³An additional two trees were cut by vandals.⁴An additional 10 trees were cut by vandals.

thereafter to 207 ft²/ac (47.5 m²/ha) at age 72. In the treatment plot, basal area was decreased by 198 ft² (45.5 m²) in four thinnings.

Total volume production of the thinned stand and the control are shown in Table 3. Total volume in the control peaked at 8190 ft³/ac (573 m³/ha) at age 67. During the most recent remeasurement (1986), mortality exceeded growth by 187 ft³/ac (13.1 m³/ha), while an additional 126 ft³/ac (8.8 m³/ha) was lost in 10 small trees cut by vandals. In the thinned stand, residual volume plus thinnings reached

10,832 ft³/ac (758 m³/ha) at age 72, with no decrease in volume production yet apparent. These data confirm findings elsewhere that thinning can salvage mortality and thereby increase net yield, but it cannot increase the total volume production of a fully stocked stand.

Merchantable volume (ft³ and fbm) in the control also reached a maximum at stand age 67. Since mortality was greatest for small trees, however, the decrease in merchantable volume was much smaller than that in total volume. In the thinned plot, merchantable volume has continued to increase.

Table 2. Mean stand height and diameter values by age from seed.

Age from seed (yr)	Year ¹	Avg DBH				Avg Height			
		Thinned		Control		Thinned		Control	
		in.	cm	in.	cm	ft	m	ft	m
27	1938 BT	6.2	15.7	6.1	15.5	42	12.8	42	12.8
	T	5.5	14.0						
	AT	6.1	15.5			42	12.8		
32	1943	7.0	17.8	6.6	16.8	48	14.6	47	14.3
40	1951 BT	7.7	19.6	7.0	17.8	58	17.7	57	17.4
	T	6.8	17.3						
	AT	8.1	20.6			59	18.0		
45	1956	8.5	21.6	7.4	18.8	66	20.1	63	19.2
50	1961 BT	9.1	23.1	7.8	19.8	71	21.6	69	21.0
	T	8.3	21.1						
	AT	9.2	23.4			71	21.6		
55	1966	9.8	24.9	8.2	20.8	77	23.5	75	22.9
60	1971 BT	10.2	25.9	8.6	21.8	81	24.7	79	24.1
	T	9.3	23.6						
	AT	11.1	28.2			83	25.3		
65	1976	11.7	29.7	9.0	22.9	88	26.8	87	26.5
70	1981	12.3	31.2	9.4	23.9	89 ²	27.1	88 ²	26.8
75	1986	13.1	33.3	9.8	24.9	90 ²	27.4	90 ²	27.4

¹BT, before thinning; T, thinning; AT, after thinning.

²Tallest 10%.

Table 3. Total volume production.

			Volume	
			ft ³ /ac	m ³ /ha
Thinned stand	1986	standing volume	5,395	378
		thinnings	5,437	380
		mortality	265	19
		total	11,097	777
Control	1986	standing volume	8,003	560
		mortality	3,440	241
		total	11,443	801

Figure 1 shows a comparison of the yield (total volume in ft³/ac and m³/ha) of the Rockland plots with that from unthinned plantations in southern Ontario (Beckwith *et al.* 1983) and at Petawawa (Berry 1984), and from thinned stands in Minnesota (Buckman 1962). To obtain a value for total age from seed, plantation age of the Rockland plantation was increased by 3 years (3+0 stock), and that of the southern Ontario and Petawawa plantations by 4 years (2+2 stock). Although production by the thinned Rockland plot corresponds closely to that of the unthinned plantations and the

Figure 1. Comparison of the total volume of Rockland plantation plots with normal yield of unthinned plantations in Ontario and thinned stands in Minnesota.

thinned Minnesota stands, the yield of the unthinned Rockland plot shows a different trend. Starting at 55 years from seed, the mean annual increment in the unthinned Rockland plot shows a decline that is much greater than that predicted by Beckwith *et al.* (1983) or Berry (1984). Though it is possible that mortality in the unthinned Rockland plot was greater than that in other red pine plantations, it is also possible that the yield in other unthinned red pine plantations will decline more sharply than predicted. Because the Rockland plantation is the oldest red pine plantation in Ontario with a recorded history of stand development, this is the first plantation in which a decline like this has been documented.

Management Implications

The economic analysis of the Rockland data (to 57 years from planting) showed that financial maturity at 4% and 6% rates of interest was highest in both plots at 47 years from planting despite continuing growth (von Althen *et al.* 1978). Height growth in both plots ceased between stand ages 67 and 72 years. During the same period, diameter growth increased total cubic-foot volume of the thinned plot by 551 ft³/ac (38.6 m³/ha). Because this volume was concentrated in only 154 trees per acre (388/ha), the unit value per tree continued to increase. In the control plot, mortality exceeded growth by 187 ft³/ac (13.1 m³/ha) during the same period. Until age 67, mortality was confined mainly to small, suppressed trees and had little effect on merchantable volume. During the last 5-year period, however, mortality exceeded growth by 166 ft³/ac (11.6 m³/ha), an indication that the unthinned stand has passed its point of physical maturity.

Thinnings have maintained a healthy stand with adequate growth 72 years after planting, whereas the unthinned stand has passed its optimal rotation age and probably should have been harvested between 50 and 60 years after planting.

Acknowledgments

The authors thank D.J. McGuire and C.F. Robinson of the Petawawa National Forestry Institute for collecting and compiling the 1986 data.

References

- Anon. 1948. Form-class volume tables. (Second ed.) Can. Dep. Mines and Resour., Mines, For. and Sci. Br., Dom. For. Serv., Ottawa, Ont. 261 p.
- Beckwith, A.F., P. Roebelen and V.G. Smith. 1983. Red pine plantation growth and yield tables. Ont. Min. Nat. Resour., Toronto, Ont., For. Res. Rep. 108. 70 p.
- Berry, A.B. 1984. Volume and biomass yield tables for unthinned red pine plantations at the Petawawa National Forestry Institute. Dep. Environ., Can. For. Serv., Chalk River, Ont. Inf. Rep. PNFI-X-32. 27 p.
- Buckman, R.E. 1962. Growth and yield of red pine in Minnesota. USDA For. Serv., Lake States For. Expt. Stn., St. Paul, Minn. Tech. Bull. No. 1272. 50 p.
- Mulloy, G.A. 1943. Growth of red pine plantations under management. Can. Dep. Mines and Resour., Dom. For. Serv., Ottawa, Ont. Silv. Leaflet No. 17. 2 p.
- Mulloy, G.A. 1946. Thinning red pine, Rockland, Ontario (1943). Can. Dep. Mines and Resour., Dom. For. Serv., Ottawa, Ont. Silv. Res. Note No. 79. 29 p.
- Sisam, J.W.B. 1939. Thinning and pruning experiment, red pine plantation, Rockland, Ontario. Can. Dep. Mines and Resour., Dom. For. Serv., Ottawa, Ont. Silv. Res. Note No. 57. 35 p.
- Stiell, W.M. 1953. Thinning and growth in a red pine plantation. Can. Dep. Resour. Devel., For. Br., Div. For. Res., Ottawa, Ont. Silv. Leaflet No. 75. 5 p.
- Stiell, W.M. 1957. The Rockland red pine plantation. Timber Can. April 1957. 4 p.
- von Althen, F.W. and W.M. Stiell. 1965. Twenty-three years of management in the Rockland red pine plantation. Dep. For., Ottawa, Ont. Publ. No. 1123. 20 p.
- von Althen, F.W. and W.M. Stiell. 1982. Update on the growth and yield of the Rockland red pine plantation. For. Chron. 58: 211-212.
- von Althen, F.W., W.M. Stiell, and R.B. Forster. 1978. Effects of four thinnings on the growth, yield and financial returns of a 62-year-old red pine plantation. For. Chron. 54: 253-260.

Journal Bargains for Institute Members!

The Table of Contents of the Canadian Journal of Forest Research is carried every month in The Forestry Chronicle. Members are reminded that this prestigious forest research publication is available to them at a very special price of \$36.00 per year. The normal rate for Canadian individual subscribers for this Journal direct from NRC is \$74.00 per year in Canada and \$94.00 per year in all countries. Here then is another advantage of membership — a saving of 106% of 161% on the price of a subscription to Canadian Journal of Forest Research. Indeed, all NRC Journals are available to CIF Members at greatly reduced prices. Not for all members to be sure but a real saving for some.

Send your order and cheque to the National Office.

360 mooney street
thunder bay, ontario
P7B 5R4

FOREST RESOURCE

— Inventory, Surveys and Evaluations

REFORESTATION EQUIPMENT

— Sales Service Parts Repair

REGENERATION & SITE PREPARATION

— Contract Assessment Consulting

Tele 807-344-0811 Fax 807-345-3440

Toll free 1-800-465-3001